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13. ABSTRACT (Maximum 200 words)

The effort has had several components since it was initiated in Oct of 1989; all of these had as their objective the assistance of Dr. Joseph Shang at WRDC in the redirection of his effort toward use of massively-parallel architectures. The major objective was to gain algorithm experience in conversion of two Air Force production CFD codes to a general format applicable to a variety of commercial message-passing architectures. Earlier, an explicit N-S 3D code from WRDC had been converted to the NCUBE. This was used as a model for parallelized production code developed at WRDC under DARPA sponsorship. This effort was completed with the conversion of a serial full 3D Navier-Stokes Beam-Warming CFD code to a 1024-node scalar NCUBE hypercube at SANDIA (Albuquerque).

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~~Interim~~ Technical Report

for Period 10-15-91 to 10-14-92

Grant AF-AFOSR-90-0020

MASSIVELY-PARALLEL COMPUTATIONAL FLUID DYNAMICS

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December 8, 1992

I. Progress Report

Goal

The effort has had several components since it was initiated in 10/89; all of these had as their objective the assistance of Dr. Joseph Shang at WRDC in the redirection of his effort toward use of massively-parallel architectures.

Previous progress

The major objective was to gain algorithm experience in conversion of two Air Force production CFD codes to a general format applicable to a variety of commercial message-passing architectures. Earlier, an explicit N-S 3D code from WRDC had been converted to the NCUBE. This was used as a model for parallelized production code developed at WRDC under DARPA sponsorship. This effort was completed with the conversion of a serial full 3-D Navier-Stokes Beam-Warming CFD code to a 1024-node scalar NCUBE hypercube at SANDIA (Albuquerque)[1].

1991-1992 progress

The following were grant-sponsored efforts.

(1) **CFD-based Computational Electromagnetcs (CEM) on parallel systems**. Recently-proposed CFD-related numerical procedures by Dr. Shang on new methods of solving Maxwell's equations in real time were examined for their solvability on parallel systems. In previous years of grant effort, Dr. Shang forwarded 2-D and 3-D explicit CEM codes for study. These were found by Dr. Shang to have numerical problems and were put aside before parallelization.

In the summer of 1992, Dr. Shang forwarded a new suite of three CEM codes for parallelization. An attempt to port these to a recently-purchased KSR at the University was put aside when it became clear that the level of KSR compiler support would not permit efficient parallelization. It was agreed with Dr. Shang that remaining effort should be spent on the DELTA, which had achieved a reasonable level of hardware stability and compiler efficiency. Experience on the KSR was useful in giving insight, however. In the process of preparing a code to exploit the KSR's automatic parallelization ("tiling"), a version of the code was developed which could be readily converted to a message-passing machine like the DELTA.

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[1]The grant was scheduled to terminate on 10/14/92. A 1-year no-cost extension has been approved.

As a result, a two-step algorithm- and code-development procedure was developed. In step (1) Professor Calahan carry out most parallelization on a reliable uniprocessor mainframe with familiar and sophisticated debugging tools; the appropriate DELTA message-passing libraries were emulated where necessary. In step (2), this code was converted to the DELTA, principally a syntactic step, involving Dr. Shang's CEM staff at WRDC. When the grant terminates, these application researchers will then be able to carry on independently. Student assistants at the University are also involved in this final parallelization step. It is expected that these three codes will be completely parallized by 3/31/93 [1]. A paper abstract on this topic, joint with WRDC, has been submitted [2].

(2) <u>Distributed CFD implicit code</u>. Based on experience with the above-mentioned two-step process, it was felt reasonable to re-institute a project to parallelize a prototype implicit CFD code for the DELTA; a previous parallelization for the NCUBE [1] was deemed inappropriate due to the relatively long message startup of the DELTA. This project had languished due to inability of finding a student sufficiently experienced to carry out the somewhat involved parallelization. It is now felt that the above two-step parallelization process involving Professor Calahan in the emulation step will make parallelization possible with modest student and WRDC help in the final parallelization step. Again, WRDC involvement will have an important educational value.

We now have in hand the most recent implicit N-S production code from WRDC. Successful parallelization will permit DELTA or PARAGON solution within the 3-year period of a DARPA contract with the WRDC CFD group.

II. Coupling Activities

Air Force Flight Dynamics Laboratory

Bi-monthly visits are made to WRDC to discuss the above-memtioned CEM and CFD codes.

III. References

[1]Kominsky, Paul, "Performance Analysis of an Implementation of the Beam and Warming Implicit Factored Scheme on the NCUBE Hypercube," Proc. 3rd Symposium on Massively Parallel Computation, College Park, MD; Oct. 8-10, 1990; pp 119--126.

[2]Shang, J., K. Hill, and D. Calahan, "Performance of Characteristic-based, 3-D Time-Domain Maxwell Equation Solvers on a Massively-Parallel Computer," conference abstract sent 10/92.